Exploring a Possible Regulatory Environment for the Private Production of Electricity from Renewable Sources in South Africa: Lessons from European Case Studies.

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Abstract

The South African government has indicated their desire to increase the private production of renewable electricity and are thus in need of policy advice. This paper draws on lessons from select European countries, each of which have experimented in the use of various policy instruments and measures to foster private renewable power generation. Particular attention is given to the use of tradable credits and feed-in tariffs. The main results found are that both achieve efficient outcomes when implemented correctly but a feed-in-tariff system is easier to monitor and due to price stability, investments therein attract cheaper capital. Competitive distortions can occur when the power grid is owned by separate regional companies as it is in Germany. This is not a concern in South Africa which has a publicly controlled grid under the ownership of Eskom.
In conclusion the recommendations reached are that South Africa should implement a system of feed-in tariffs with the possibility of subsidies for technologies less mature than wind, such as solar.

KEYWORDS: FEED-IN TARIFFS, CARBON, RENEWABLE, TRADABLE CREDITS

1. Introduction

Climate change and resource depletion are some of the largest problems facing the modern world economic system. Many of the industrialised nations have responded to this challenge with various policy measures aimed at reducing the carbon intensity of their economies. However, climate change is predicted to affect the poorest nations, which lack the resources to mitigate its effects, the most. It is not enough for the developed countries to reduce their emissions as an increasing share of emissions is coming from developing countries. In addition to the eventual depletion of fossil fuels, climate change has increased the need for countries to begin searching for renewable alternatives in electrical power generation.
Renewable energy production is the harnessing of natural flows of energy in the forms of wind, solar, biomass, hydro and geothermal. The Intergovernmental Panel on Climate Change (IPCC) has estimated that the global renewable energy potential well exceeds the current demand (IPCC 2001: Chapter 3). The realisable potential is far lower, however. It is limited by the costs of the technologies, the relative efficiencies and the market conditions. For instance, the production of electricity using non-renewable fossil fuels has been justified by consistently underestimating the externality costs. The relatively high costs associated with renewable technologies have made their use a prohibitive luxury (U.N., 2004). Market intervention is necessary if the private sector is to competitively and affordably provide renewable energy alternatives.
The potential rewards for the diversification and production of renewable energy is increasingly becoming a policy priority in South Africa. Eskom, the primary electricity producer for South Africa, is experiencing strain on its aging grid and is struggling to keep pace with capacity rollout. As the current least cost producer of electricity in the world, it is estimated that Eskom has been producing the bulk (83% of its generating capacity in 2006) of South Africa's power using coal (Winkler et al., 2006). In addition, South Africa is the largest per capita emitter of green house gasses in CO_2 equivalent measures in Africa (Houghton, 2002).
European countries have responded by implementing policies which seek to create a market for renewable energy. The success has varied greatly depending on the metric used in analysis. Some countries achieved rapid cost reductions with a negligible rollout while others established a rapid and large rollout facilitated by a stable investment climate. It would be prudent for South Africa to learn from these front runners. This paper makes use of four countries as case studies, chosen

notably for their success in different categories and draws lessons for the way forward with South Africa's renewable energy policy. The four countries chosen are:

1. **Germany**, for its rapid expansion of mostly wind technology. In later implementations Germany also managed to reduce the cost to the public while increasing generative diversity.
2. The **United Kingdom** achieved the largest cost reduction of the four by a large margin using a market based credit trading arrangement as well as a system of bidding production rights
3. **Spain's** policy makers placed a large emphasis on the stable and reliable production of renewable energy. Spain has arguably achieved the largest diversification of renewable energy production methods employed as well as a careful, even spread of production capacity across the country (Sijm, 2002).
4. **Denmark's** policies have been shaped as much by economic theory as it has by lessons from the rest of Europe. While installed wind capacity has been eclipsed by Spain and Germany, Denmark still boasts the highest per capita production of renewable energy in the world (Sijm, 2002).

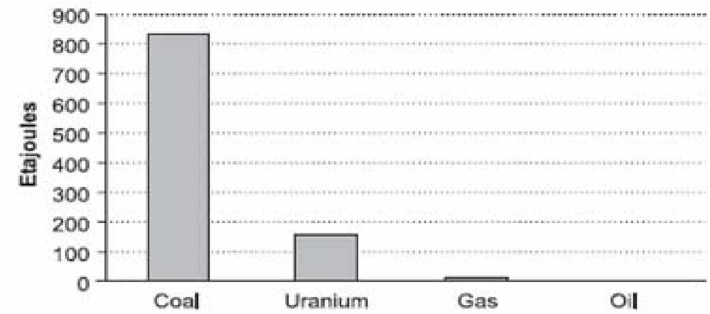
The common policy instruments used in each of the above countries ranges from feed-in tariffs to a system of tradable credits. A feed-in-tariff is an agreed upon price paid to producers of renewable energy to feed their energy into the national electricity grid. Credits, on the other hand, are issued to producers of renewable energy for every kilowatt-hour (KWh) of electricity produced. Producers or consumers of fossil-fuel based electricity are then obliged to buy a certain quota of credits, usually traded through a central exchange. Market forces determine the value of the credits which act as a subsidy for renewable energy production. Both forms of policy, which are justified by neoclassical theory, are isolated and scrutinized in each case. Some important results from the case studies include the previously underestimated importance of stable investment and policy climates for renewable energy as well as the need to guard against competitive distortions.

The next section contains some general information regarding the natural resource endowments of South Africa as well as the energy composition of its economy. Section 3 then starts by giving brief but complete definitions of feed-in tariffs and carbon credits and their theoretical implications. Section 4 outlines the policy evolution in each of the European countries and assesses their relative successes. Section 5 draws insights from these lessons in the context of South Africa's stated objectives and current policy initiatives. Finally section 6 concludes by drawing all this together and provides policy and implementation recommendations for the South African government.

2. The Background to South Africa's Energy Regime

South Africa is endowed with a diverse set of natural energy resources. Prior policies, however, were focused purely on observed costs as a means of attracting investment. The bulk of electricity is thus still produced by coal generation techniques. Coal is not only the cheapest source (excluding externality costs) but also the most abundant. Figure 1 shows the remaining reserves of each non-renewable electricity resource in South Africa as measured by their energy content.

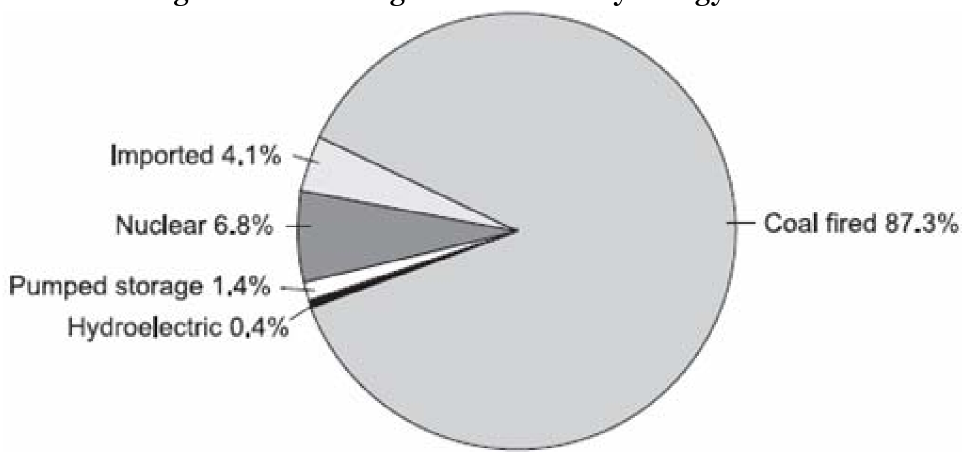
Figure 1: The remaining reserves of non-renewable energy sources.



Source: Winkler et al., 2006

Eskom, the producer of 91% of South Africa's electricity at the end of 2000, employed coal driven power stations as its primary source of energy production (NER , 2001a). Figure 2 shows that this figure was as high as 87%.

Figure 2: Eskom's generation mix by energy source

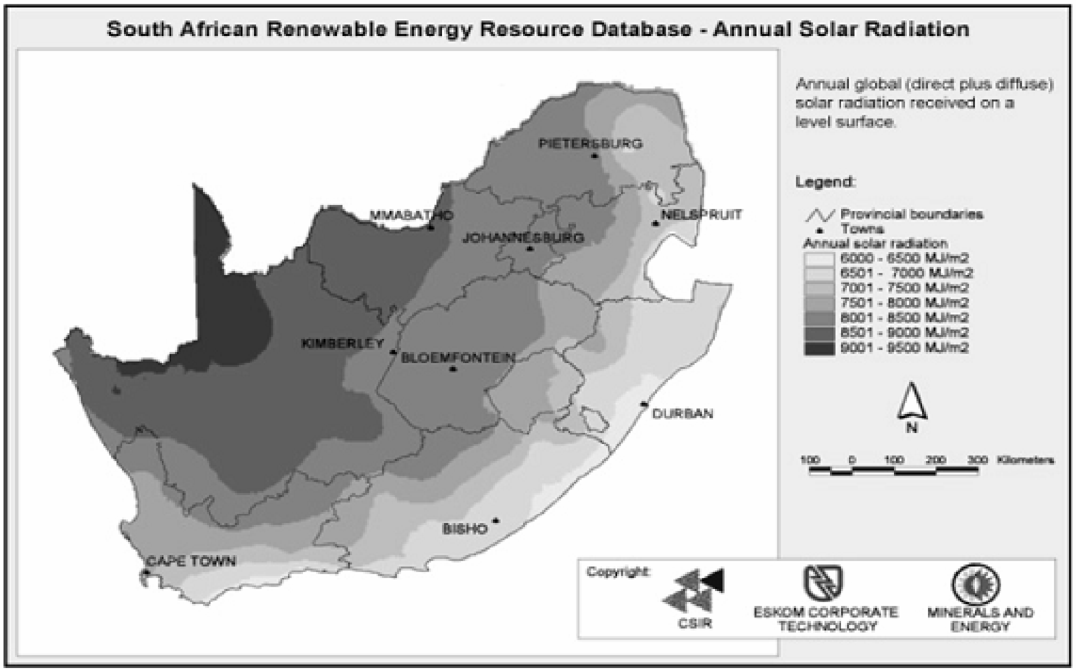


Source: Winkler et al., 2006

Unlike most of Europe, South Africa is mostly dry and arid. There is a significant amount of bagasse (the unused flammable part of sugar cane) to provide excess power generating capacity. South Africa produces about 7 million tons of bagasse annually with a heating value of 6.7MJ/kg (Winkler et al., 2006). Europe has had mixed results with solar generation, with Spain being the notable exception. This is in no small part due to the low solar intensity in the northern latitudes. South Africa is set to take advantage of large and abundant solar resources. The average annual solar radiation for South Africa is 220w/m^2. In the USA some of the hottest parts are 150w/m^2 in comparison. In Europe the average is around 100w/m^2 (Winkler et al., 2006). Figure 3 gives the solar distribution of South Africa. It should be noted that the Northern Cape experiences some of the highest solar radiation intensities in the world.

South Africa differs greatly from its European counterparts in the availability of solar radiation, relative to wind. The theoretical potential lies somewhere around 280 terawatts (Eberhard & Williams 1988: 9). The potential for wind however is less than 1% of this. This contrast is particularly pronounced in the arid and less windy interior of the country.

Figure 3: Annual Solar Radiation across South Africa



Source: Department of Minerals ad Energy et al (2001)

According to the Department of Minerals and Energy (DME), the best wind resources can be found along the coastal regions (DME et al., 2001).

There is sufficient scope for the rollout of renewable energy to rural and poor areas in South Africa. Coal, kerosene and wood are often used as major cooking fuels. As these products become more expensive the need for decentralised production of affordable energy will arise. It was estimated in 2006 that up to 50% of rural households had no access to electricity in South Africa (Winkler et al, 2006).

3. Definitions and Theoretical Implications

A feed-in-tariff is a stipulated obligatory price paid to wholesale producers of renewable electricity by power utility or grid controlling companies in return for the right to retail that energy to the public.[1]

An alternative to regulating the price and allowing the greenhouse gas emissions to adjust is to set a limit on greenhouse gasses and allow the price to reach equilibrium. This is done through a system of tradable credits known as carbon credits, green certificates, renewable obligation certificates and so on. The principle of a carbon credit, as stipulated by the Clean Development Mechanism (CDM), is that a certificate, which is worth a certain amount of CO_2 (usually a metric ton) is awarded to a producer of renewable energy for producing power that would have emitted a

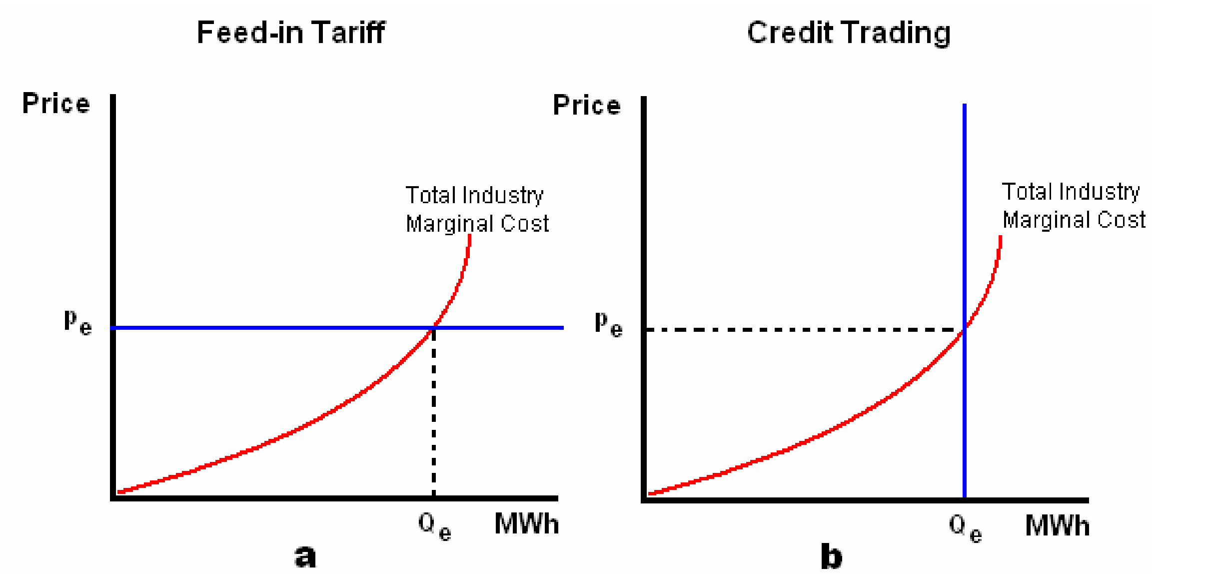
[1] This is a general definition. The following definitions, which expand on the above and clarify ambiguous details, are all valid:

a) A regulatory minimum price per kWh paid to private producers of renewable energy.
b) A regulatory minimum price per kWh paid to private producers of renewable energy as well as tax rebates or subsidies.
c) A premium paid over and above the usual tariff to producers of renewable energy. (Monthorst, 1999; Huber, C., T. Faber, R. Haas, and G. Resch, 2001; Haas et al, 2001)

metric ton equivalent of CO_2 had it been produced conventionally, usually through coal fired plants.[2]

In the narrower form of electricity generation it is administratively feasible to award a credit for every kilowatt-hour (kWh) or megawatt-hour (MWh) of renewable energy produced. A polluting party (usually a utility company; in some cases the consumer) is then obliged to offset a certain portion of its electricity production/consumption with credits. To facilitate a competitive environment the credits are traded on a central exchange. The value is determined by market forces. The renewable energy credit thus acts as a market based tariff paid to producers of renewable energy.

Figure 4: Market Outcomes under 2 Systems



These two systems are chosen primarily because neoclassical economic theory predicts that both are optimal and efficient. As figure 4 illustrates, either the cost of renewable energy is set under a system of feed-in tariffs or a quantity of emissions or renewable energy output is set nationally and credits are traded so as to set the price according to market conditions. Under a feed-in-tariff firms will produce renewable energy until their marginal cost of production is equal to the regulated tariff. In panel **a** this occurs at an output of Q_e MWhs. The main assumption underlying this equilibrium is that marginal costs are increasing. Given the need for a suitable location, such as a windy coastal region for wind energy production, large scale renewable operations can safely be assumed to have this static cost property. Another important efficiency point to note according to Huber et al. (2001) is that a producer of renewable electricity should only receive a guaranteed tariff for a limited period.

A credit system fixes the amount of generated electricity, rather than the price. The initial low supply of renewable energy producers will raise the price of individual credits, attracting entry into the market. As more renewable energy firms enter the market, the industry-wide marginal cost is likely to increase, preventing the entry of additional firms. If the quota of renewable energy is not met (i.e. some firms haven't met their obligations) then the price of the credits will be bid up until further entrants arrive. The price of the credits will eventually adjust to P_e in panel **b** so that the targeted amount of renewable energy is produced. At this point all polluting firms have met their obligations. In theory, if the amount of tradable permits its set to Q_e then the market outcome is

[2] For more on the clean development mechanism *see* http://cdm.unfccc.int/index.html

identical to the case where a feed-in tariff is set at P_e. What has emerged is that one of the main assumptions here is free entry and exit from the market with no sunk costs. As we shall see later, the volatile price of the tradable credits acted as a barrier to entry for many firms as the sunk costs of renewable electricity production are very large, relative to the running costs. Thus when reviewing the investment climate created under such a system, the assumption of free entry and exit might be too strong.
For this and other unforeseen impracticalities, reality often diverges from theory. The European experience should help to identify these divergences and recommend the most appropriate policy measures needed.

4. Experiences from Europe

Before outlining the initiatives undertaken by the four European countries it is worth looking back to the earliest use of policy instruments in mitigating climate change. California was the first to draw up legislation encouraging the private production of renewable energy under the Public Utilities Act of 1978 (McNerney, 1998). This policy managed to promote a large scale investment in wind technology but poor design led to the eventual collapse of many wind farms (Butler and Neuhoff, 2004). They were followed shortly by Denmark but it was not until the beginning of the 1990's that European countries began to make a significant impact on the composition of their own power generation. As most European power companies are privately owned the respective governments found it politically feasible to implement policies of regulation as a means of correcting for market failures, rather than establishing publicly owned renewable energy companies. These could then be overseen by various regulatory bodies. The aim of the policies was to internalise the cost of the negative externality of producing non-renewable energy by imposing a tax on the consumers, producers or both, the proceeds of which were used to subsidise the production of renewable energy. Many countries experimented with a system of direct carbon taxes which were recycled as subsidies. However, the most dominant forms of market-oriented policy to be adopted were the Feed-In-Tariff and the Carbon Credit Trading Scheme.

The United Kingdom, Germany, Denmark and Spain were among the first European countries to experience a significant increase in private renewable generating capacity since implementing enabling policies. These policies have not come without their costs and market distortions. Germany's initial Renewable Energy Law, for instance, placed a disproportionately large burden of the costs on the utility companies along its windy northern coast (Sijm, 2002) while the U.K.'s NFFO created a volatile and highly competitive market which caused many renewable investments to fail. Designing sustainable policies requires a strict balance between efficiency, a stable investment climate and fairness (ensuring the costs are shared appropriately amongst the various parties involved). The selected European countries were forced to experiment with policy until the desired balance was struck between these three criteria.
Caution must be taken when comparing the relative successes of different countries as certain key factors vary significantly. The regulatory environment concerning zoning and development might significantly affect the pace of development. Similarly, comparing the power generated might be misleading due to unequal natural resource endowments. Germany, for instance has an average wind speed of $5.5 m.s^{-1}$ while the U.K. experiences wind speeds on average of $8.3 m.s^{-1}$ (Dale et al., 2004). A fairer measure here might be installed capacity. Given the difficulties of comparison it is safer to first assess each nation individually. Later, comparisons can be made, not on absolute metrics such as total generated power, but on whether the national objectives were met efficiently.

The relative success of each nation's renewable energy policy can be judged primarily on the attainment of the initial goals it set itself. To this end Germany's EFL was completely successful in that its sole purpose was to increase the share of renewable energy in the national production. However, cost to the public as well as economic efficiency is just as important if the policy is to be sustainable. Given the finite nature of traditional fossil fuels maximum capacity of installed MWhs of renewable energy is possibly one of the largest criteria of success in the long run. This section reviews the policy experience of each of the selected countries separately. First the policy progression and national objectives are laid out, followed by an evaluation of the effect these policies had in achieving the desired results.

United Kingdom

Starting in 1990 the U.K. adopted the non-fossil fuel obligation (NFFO) policy. Firms wanting to sell renewable electricity onto the grid were required to bid for production rights. The Department of Trade and Industry (DTI) determined the targeted capacity for each technology and accepted the lowest priced bids. Regional Electricity Companies were obliged to buy any renewable electricity offered to them by the successful bidders at the price per mega-watt hour (MWh) contracted by the DTI. Should the price paid to these firms exceed the retail electricity price the difference would be covered by the Fossil Fuel Levy, a tax levied on consumers of electricity.

Over the course of the NFFO there were four rounds of bidding of this nature. The purpose of having multiple rounds was to ensure that technological advances and competitive bidding environments forced the prices down over the period.

The NFFO was augmented in 1998 by a system of ROCs. Firms no longer had to bid for the right to sell renewable energy but simply had to be deemed eligible by the DTI. After receiving such recognition a firm was awarded one ROC for every MWh of electricity produced. Energy suppliers were obliged to buy ROCs equal in quoted power value to a certain portion of their electricity sales. In 2002 this was set at 3% (Butler and Neuhoff, 2004). Companies which failed to meet their obligation were fined on the uncovered power (£30/MWh in 2002) which acted as a price ceiling. The system followed market principles so that entry by renewable firms would push the price of ROCs down toward the true cost of production while ensuring that a certain target portion of the nation's electricity was generated renewably. The goal, which was set at 3% initially, increases every year so that by 2010 10.4% of electricity is generated renewably (Butler and Neuhoff, 2004).

Butler and Neuhoff (2004) found that the NFFO succeeded in driving down the price of renewable energy in the U.K. during the initial phase in the 1990's by between 0.57% and 0.67%.[3] In each round of bidding the DTI set a target of declared net capacity, starting with 1500MW in 1993 (Butler and Neuhoff ,2004). The installed capacity in the U.K. increased from 10MWs in 1990 to 649MWs by the end of 2003 (IEA, 2004). Thus the targets were never met under the initial NFFO. The introduction of the ROC was, among other things, expected to increase installed capacity.

One of the major implications of the ROC system is that the technology with the lowest cost is used due to competitive pressures. This leads to economic efficiency but low diversity in generating techniques as wind is the cheapest which raises reliability issues during periods of low wind speeds. Since the introduction of the ROCs installed capacity has risen by 60MWs.

To counter the issue of reliability New Electricity Trading Agreements were created in the U.K. to penalise intermittent transmission and reward reliable transmission with premiums (Mitchell and Connor, 2004). This placed a heavy burden on small firms and start-ups. A survey of developers of

[3] Using a subjective discount rate and adjusting for subsidies the estimated cost reductions were calculated over a 20 year period. *See Butler and Neuhoff, 2004*

renewable plants conducted in 2004 found that obtaining finance under the ROC was more difficult than under the fixed prices of the early NFFO due to revenue uncertainty[4].

Germany

From the beginning Germany chose a strict path of feed-in tariffs, never experimenting with credit trading of any type. In January 1991 the Stromeinspeisungsgesetz (Electricity Feed Law, EFL) came into effect. The tariffs were paid by the obliged grid companies to all producers of solar and wind. The tariff was set at 90% of the average final price paid by consumers over all the previous years except the last (Sijm, 2002). For sources other than solar and wind the tariff was set at lower rates. In 1998 the EFL was amended with a 5% hardship clause which in essence meant a utility was not obliged to buy electricity beyond a share of 5%. There were other smaller incentives such as preferential interest rates provided to renewable producing firms.

Throughout the 1990's the price of electricity declined due to deregulation, resulting in lower payments to renewable generation firms (Butler and Neuhoff, 2004). This prompted the passing of the Erneuerbare-Energien-Gesetz (Renewable Energies Law, REL) in 1998 which became effective in 2000. Under this system a fixed tariff was specified for wind and solar separately. The tariff declines after 5 years of operation each year by 1.5% after 2002. This was put in place to accommodate technological progress and learning in the implementation of these technologies. These predictable, declining tariff structures were intended to create a stable investment climate while promoting cost efficiency gains.

Under the EFL installed wind capacity doubled annually between 1990 and 1995, decelerating to 40% annual growth from then until 2000 (Sijm, 2002). Most wind generating capacity was installed in high wind speed areas. Utility companies in windier regions such as the northern coast had a far larger cost burden than the average utility company which led to competitive distortions. The initial tariff was too low to encourage solar which led to the same diversification problems experienced under the U.K. ROC (Sijm, 2002). Producers of renewable energies were insulated from certain market pressures by a fixed tariff which led to price inefficiencies. With no decline in the tariff there was no incentive for cost reductions through technological progress.

The introduction of the REL sought to address these problems through 2 major changes. Firstly, a system of stepped tariffs were introduced which provided high tariffs to low wind areas and low tariffs to high wind areas. This spread the cost burden of the northern windy coastal wind farms more evenly across the country. Second, the tariff paid to renewable producers would decrease, after an initial investment, annually. This stepped decrease also served to reduce the continual reinvestment along the northern coast as new investments would be rewarded with higher tariffs. Under the REL installed capacity has risen from 4500MW in 2000 to 14609MW by 2004 (IEA, 2004).

Denmark

From the 1990's Denmark followed a system of feed-in tariffs accompanied by state subsidies, consisting of a recycled carbon tax as well as a production subsidy. For wind energy the tariff was set at 85% of the final price of electricity sold in that area (Schaeffer, et al., 1999).

The increasing public cost prompted the Danish authorities to shift policy toward a market-oriented path.[5] From 2000 existing renewable firms were to receive reduced tariffs accompanied by

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[4] The survey was carried out by LEK consulting for the Carbon Trust. *See Butler and Neuhoff, 2004*

[5] The total subsidies and avoided tax in 1998 surpassed €75million in Denmark (Monthorst, 1999)

green certificate payments. New entrants were required to participate in a market system similar to the ROC system of the U.K. mentioned above. By 2013 a reformed market based system is set to replace the feed-in tariffs as the main source of income to renewable energy producers. The green certificates are to be sold by firms on the national stock exchange. All consumers of electricity are obliged to buy an amount of green certificates equal to a certain portion of their annual consumption (Odgaard, 2000). The competitive market forces are expected to drive down the public price of renewable energy. The cost burden is thus shared between consumers and non-renewable producers.
Offshore and biomass energy will follow a system of tendered bids, similar to early rounds of the NFFO. The Danish system of policies to promote renewable energy is thus a seamless hybrid of the German and British schemes.

Under the system of feed-in tariffs and subsidies before 2000, transfers and payments to producers of renewable energy were high enough to provide an internal rate of return of between 5% and 22% for a 600kW turbine, depending on the location. With a normal discount rate of 3.25% this made investment attractive even in low wind areas (Monthorst, 1999). Over the period 1990-2000 installed wind power capacity in Denmark grew at an average rate of 21% annually. By 2000 it had the highest wind power per capita in the world (Sijm, 2002). The new system of tradable green certificates has yet to come into full effect as it was currently in the transition phase at the time of writing. It has therefore not been assessed in its entirety.

Spain

In 1994 Spain implemented a premium feed-in-tariff. Power companies were obliged to buy renewable energy from eligible firms but unlike the German and Danish system, which left room for profitability, the Spanish tariff was paid in addition to the market price of electricity.[6] The burden of payment fell squarely on the grid companies with no rebates or subsidies granted. This was achieved politically because the grid companies were state owned. The state-owned grid companies thereby set the price of the tariffs (Ragwitz and Huber, 2007). Tariffs are only guaranteed for 1 year, potentially raising the risk to investing.
From 2004 a new legislation was implemented, known as the Royal Decree 436/2004 (Ragwitz and Huber, 2007). Under this decree renewable production firms could choose between a regulated payment scheme and a sale on the free market, facilitated by a bidding system. Renewable energy production firms are required to provide distributors with a 30 hour forecast of supply, upon which deviation incurs a penalty. A tolerance band of 20% for solar and wind is stipulated in the decree.
Different technologies were awarded different tariffs so as to promote production diversity and possibly avoid overreliance on one possibly intermittent form of energy production. Table 1 contains the tariff premiums awarded to each technology.
The Spanish thus put a high premium on reliability of supply.

[6] In 2000 this amounted to more than €3c/KWh (Haas, et al., 2001)

Table1: Fixed Prices and Premiums for various technologies.

YEAR 2004		FIXED	
		Fixed Prices	Premiums
		(€/MWh)	(€/MWh)
Solar Thermoelec-tric		216.216	180.180
Primary Biomass	Energy crops	64.865	28.829
Secondary Biomass	Forest residues	64.865	28.829
	Biogas/ sludge	64.865	28.829
	Agri. & forestry industries	57.658	21.622
Wind Energy	Onshore	64.865	28.829
	Offshore	64.865	28.829
Geothermal	< 50 MW	64.865	28.829
Small Hydro	<= 10 MW	64.865	28.829
	> 10 MW to <= 25 MW	64.865	28.829
	> 25 MW to <= 50 MW	57.658	21.622
Solar Photovoltaic	<= 100 kW	414.414	
	> 100 kW	216.216	180.180

Source: Royal Decree 234/2004 12th March (Spanish Official Gazette, 27th March 2004).

Spain also paid a system of stepped tariffs according to the average yield. For instance wind farms in windy areas were paid less per kWh than firms in less windy areas. This promoted a nation-wide spread of renewable energy.

Between 1995 and 2000 installed wind capacity doubled every year, starting at 114MW and reaching 2800MW (Sijm, 2002). The variability in year to year tariffs would certainly have added an element of risk to investments in Spanish renewable energy production but, as Ragwitz and Huber (2007) note, the stable political environment surrounding the system possibly offset this to a degree. Compared to the U.K. and Germany Spanish renewable energy diversity and reliability are very high.

The feed-in-tariff created a stable investment climate in Denmark, Spain and Germany, lowering interest rates and the cost of capital. This, along with technological improvements and learning significantly reduced costs for producers as compared to their credit trading counterparts in the U.K. and over time as the investment climate was more predictable over the long run (Sijm, 2002). However, cost reductions could not be passed onto consumers under a fixed tariff which bore no relation to underlying costs. The response of Germany was to mandate a gradual decline in prices to accommodate the cost improvements. This was still less perfect than a market outcome as regulators who had little knowledge of the underlying costs set the tariffs. Furthermore, regulators found it politically difficult to reduce the price in the face of strong opposition from the power companies (CEC, 1999). Feed-in tariffs have been very successful in producing wind energy but not much else due to the cost effectiveness of wind. In both Spain and Germany the differentiation of tariffs for certain technologies was required to offset this effect.

It was mentioned earlier that the regulated price should decrease over time so that cost savings can be passed on to consumers. Sijm (2002) contends that the optimal rate of decline should match the learning curve of the technology in question[7]. The more mature technologies have a flatter learning

[7] Simply put, the learning curve of a technology is the rate at which the knowledge of implementation which enables cost savings improves as well as the technological progress in capacity or cost of production.

curve than the newer technologies. To accommodate this, Germany and Spain both implemented differentiated stepped tariffs for various technologies which declined at different rates. This created room for new technologies to mature (Langniß, 2002). While the learning curve is steeply declining in the long run for most renewable technologies the short run cost curve is usually increasing. This implies that start-up firms require an initially high tariff which can only decrease once a significant critical capacity is installed which creates more problems for regulators who would prefer to set a national tariff. Germany's response to this inter-temporal contradiction was to give every producer the same initial tariff which remained static for five years after declining rapidly and stepped according to generation. The stepping down of tariffs with increases of output helped to reduce producer surplus and thereby minimize the cost to society (Ragwitz and Huber, 2007).

Feed-in tariffs have also been criticised for not creating competition amongst investors as other systems such as the NFFO have done. This then has the potential to insulate otherwise uncompetitive firms from market forces resulting in unnecessary costs passed on to consumers. Ragwitz and Huber (2007) point out, however, that the proliferation of firms producing renewable energy will create a significantly competitive market for renewable capacity manufacturers who are not insulated from market forces. The technological cost savings will thus be passed on to every renewable production firm. Still, it is premature to argue that this effect has certainly offset the investor competition-based price reductions. On the contrary, the evidence suggests that investor competition played a very important role in providing the cost savings under the NFFO in the U.K. Over the course of the 1990's the price of wind-power in the U.K. came down by 70% in real terms (Langniss, 2002).

The variability in price has been criticised as severely undermining investor confidence in the tradable carbon credit scheme. The majority of installed wind capacity in the U.K. took place during the bidding phases of the NFFO. Under the system of ROCs only 60MW of additional capacity had been added by 2004 (Butler and Neuhoff, 2004). A system of ROCs could never achieve the price stability of feed-in tariffs. Through competitive pressures, however, long run price efficiency is more likely to be achieved in the ROC framework than through the feed-in-tariff pricing, even with a regression in tariffs at a rate close to the learning curve. This is due to the asymmetry of information inherent in the tariff setting structure. Thus in the long run the feed-in-tariff can only be as efficient as the ROC if the tariff regression happens to perfectly match the learning curve.

Denmark has addressed the major flaw of tradable credits – short term volatility – by offering producers a longer term fixed price for their certificates. The market will offer long term contracts to suppliers so as to provide price stability. The long term contracts act as a feed-in-tariff except that as they will be issued on the stock exchange they will be market determined (Odgaard, 2000). This prevents over subsidisation of renewable producers and forces them to be cost competitive. As this policy has yet to be implemented it cannot be fully assessed but on the surface it appears to address the volatility constraint to investment adequately as well as providing static efficiency as high as that of feed-in tariffs and the dynamic efficiency of a tradable credit system. Due to competitive pressures, credit trading promotes only mature technologies such as wind. Feed-in tariffs have the same effect but for reasons related to profit maximization. Unambiguously wind power is proliferate in both Germany and the U.K. (Butler and Neuhoff, 2004). Experience from each country suggests that subsidies and rebates of some form are still necessary to allow less mature technologies to co-exist.

Finally, possibly one of the most important European lessons learnt is that of policy stability. Spanish firms could attract cheaper capital than German firms even though Spanish tariffs were only guaranteed for a year. The reason most cited is the knowledge that policy toward renewable energy will remain constant for the foreseeable future in Spain whereas German policy is revised every 10 years (Sijm, 2002). Renewable energy companies in the U.K. received higher payments from ROC's than from the contracts under the NFFO system. However, a survey of renewable energy developers conducted by LEK consulting in 2003 for Carbon Trust found that, due to uncertainty regarding the continuation of the policy, obtaining finance was perceived to be more difficult (LEK, 2003). The U.K. system was also strongly affected by political uncertainty which caused many investors to adopt a "wait-and-see" approach (Butler and Neuhoff).

5. Applications to South Africa

In 2002 Government released a draft White Paper on "Renewable Energy and the Promotion of Clean Development" which states the intention for the "open and non-discriminatory" access to the electricity grid for producers of renewable energy (DME, 2002). Government plans to increase the annual production of renewable energy to 10 TWh (terawatt hours) by 2013 taking into account declines in production costs due to increase global use (DME, 2002). This signalled a shift from the initial energy White Paper released in 1998 which sought the advancement of key socio-economic goals and the rollout of services to the poor (DME, 2002).

Near the end of 2003 the Department of Minerals and Energy published their Integrated Energy Plan (IEP), a blueprint for decision making and planning and diversification of energy technologies. The plan was analysed and refined by the Energy Research Institute using case-study simulations of consumption and production evolution up until 2020. The simulation takes into account the use of different technologies and the greenhouse gas emissions associated with them.

Most of the growth in conventional renewable energy production in South Africa has taken place in rural areas considered too remote and poor to warrant grid expansion. The primary means of electrification has been through solar home systems. 5321 solar home systems had been installed by 2003 (Mlambo-Ngcuka, 2003). Government is also considering an approach of mixing the use of renewable energy with liquid petroleum gas and local biomass such as wood. Presently Government is subsidising the capital and maintenance costs of off-grid solar powered home systems but the fiscal cost is high. (Winkler et al., 2006). Clearly such expansion on the economic fringes will not make a significant impact on any national targets. In response, the White Paper of 2002 sets as its objectives the need to create fiscal incentives and a stable investment climate to attract "local and foreign investment" (DME, 2002).

Policies proposed to meet these objectives included the need to create a regulatory environment to encourage the production of renewable energy by independent producers through the correct structuring of tariffs. In 2003 Government issued another white paper on renewable energy in which it is stated that by 2014 the intended proportion of renewable energy should be no less than 14% (Mlambo-Ngcuka, 2003). Government has since conceded that the centralised investment in renewable capacity is less than optimal but has maintained the need for centralised regulation and support. In late 2005 the Renewable Energy Finance and Subsidy Office was established and mandated with dispensing advice to renewable developers as well as awarding subsides and finance to eligible producers based on a set of common criteria (Winkler et al., 2006). On the regulation side, the NER has agreed to regulate the development of a renewable energy market (NER, 2002a). This perhaps alludes to Government's interest in a credit trading scheme although a strong regulator would be needed to facilitate grid access as well.

Eskom has been exploring the possibilities of promoting wind and solar generation. In 1998 it initiated the South African Bulk Renewable Energy Program (SABRE) and in 2002 it installed a 25 kilowatt Stirling engine at the Development Bank of Southern Africa's premises (Winkler et al., 2006).[8] Construction of molten salt solar farm is set to begin by 2008. Eskom is exploring the feasibility of setting up the 100MW plant in the Northern Cape, near Upington (Winkler et al., 2006).[9]

So far there are only a few, relatively small scale independent wind generation projects planned. Among these is the setting up of a 5MW wind farm in the Western Cape by the Darling Independent Power Producer (Winkler et al., 2006). The wind farm is supposed to begin operation in 2008.

In the European case studies it emerged that large expansions of capacity were only successfully achieved under stable investment conditions. In particular, the feed-in-tariff was the most effective instrument in achieving this stability. However, this has come at a high cost in Spain, Germany and Denmark. As the tariffs were set by regulators, efficiency was suboptimal and the distorted cost to the public and industry participants created a set of competitive distortions. Credit Trading eliminated problems of information asymmetry but investors placed a high risk premium on a market with unstable prices. The cost of acquiring capital in its initial phases of operation was significantly higher for firms operating under the ROC system in the U.K. than for firms under any of the fixed tariff systems elsewhere in Europe. Firms which didn't encounter problems attracting capital under the ROC system were those already established and large. Their credibility as well as spare capacity translated into far lower risk premiums.

From the counter-perspective, firms which had been operating under feed-in tariffs had in latter years experienced monopolistic rents due to the highly steep, declining long-run cost curves associated with most renewable technology. This prompted the implementation of declining tariffs in Germany's initial policy adjustments. However, matching the rate of decline in tariffs to the learning curve of the technology requires rigorous, but imperfect, analysis. Instead Denmark's response was to allow a firm a feed-in-tariff for a set period, after which a gradual phase-in of credit trading would occur. This guaranteed firms the stable investment climate in the initial phases but passed on most efficiency gains to the consumer once the firm had matured. To prevent high credit price volatility, firms would be able to buy credits with prices set according to long term contracts while still being market driven.

Both feed-in tariffs and renewable credit trading encourage the use of least-cost technologies (Butler and Neuhoff, 2004). In the case of feed-in tariffs this ensured revenue maximisation and uncompetitive rents for producers while the competitive environment of credit trading demanded cost minimisation to avoid failure. Currently wind is the most affordable and efficient technology by a rather large margin, due in part to the maturity of the technology (Sijm, 2002). This poses two major problems for South Africa in particular. The first regards the underutilisation of vast solar resources in favour of the coastal wind potential as mentioned earlier. The second is associated with reliability of using one source of energy. The intermittent and unpredictability of wind can significantly increase grid costs. The German response to diversification was to implement a set of differing tariffs so that new technologies would be insulated from competing with wind power (Ragwitz and Huber, 2007). This doesn't fully address the issue of diversification under a credit system. One solution could entail paying a small feed-in premium to producers of solar energy, for

[8] A Stirling engine is a device which creates air convection using heat absorbed through solar exposure. The convection causes a bag to inflate which drives an electric generator.

[9] Molten Salt solar plants work by concentrating solar energy onto a central tower containing molten salt using parabolic reflectors. The heat from the salt then drives a steam turbine which generates electricity. The benefit of using molten salt is that at night the salt retains its heat which facilitates 24 hour generation.

instance, while still allowing access to credit trading. The premium should be set to so as to offset the cost savings of wind technology. This is the new approach to be taken in Denmark.

6. Conclusion

Achieving the correct balance of policies requires South Africa to prioritise certain production goals. With its intention of the private sector producing 10 000 gigawatt-hours (GWhs) of annual renewable electricity by 2013 it should be noted that Government's goals are modest, given current annual production which stands at around 198 206 GWhs (NER, 2001b). As the producer of the world's cheapest electricity, in order to retain and attract investment in energy intensive industries, South Africa looks set to encourage efficiency and stability of generation over volume in its renewable goals. In order for national job creation goals to be met investment stability is crucial.

The European experience has shown that the major policy tradeoffs that must be made are between investment stability and cost efficiency. As the industry is in its infancy in South Africa the Government's goals should lie with creating a stable investment climate initially so as to attract FDI. Issues of efficiency need not be addressed until later due to the low proportion of capacity renewable production occupies. However, as the case studies have shown, the rapid proliferation that takes place in early years must eventually be addressed by efficiency adjustments. Furthermore, the incentivising of solar production should be encouraged given the country's vast solar resources. There has been much development in photovoltaic efficiency in recent years and the costs are projected to continue falling at a brisk pace (Delahoy and Chen, 2001). A suitable incubating environment can be created through the use of technology differentiated feed-in tariffs. A transition would need to be made to a system of credit trading. The Danish phase-in period possibly represents the most appropriate model for a significant, cost-effective transition. Further research is required in coming years to evaluate the success of these policies.

Policy stability should not be underestimated as an important driver of growth in the renewable industry. Without a firm commitment from Government the technologies cannot survive commercially.[10] South Africa can benefit in this regard as the incumbent government enjoys a vast majority mandate and policies designed to deal with issues of renewable production are therefore likely to be insulated from political fluctuations.[11]In South Africa the primary producer and grid owners are under one public umbrella. Mandating a system of feed-in tariffs wouldn't create any of the competitive distortions experienced in Germany and far less political uncertainty.

The South African government has repeatedly stated its intentions to further the development of renewable alternatives. With a windy coast and a very sunny interior, the setting has been created for South Africa to become a global leader in the production of renewable electricity and to play a major part in the advancement of solar technologies, in particular.

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[10] In Spain the feed-in tariffs were only guaranteed for 1 year at a time, yet the cost of attracting capital was lower than in Germany, which guaranteed a set of gradually declining tariffs over a 10 year period. The most commonly cited reasons was the policy stability in Spain as compared to other nations. The Spanish government made a 25 year commitment to producers. In Germany the policies were routinely reviewed (Sijm, 2002)

[11] Many of the decisions taken in Germany had to be carefully designed, taking into account the many affected parties (Butler and Neuhoff).

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